

****Volume Title****

*ASP Conference Series, Vol. **Volume Number***

****Author****

© ****Copyright Year**** *Astronomical Society of the Pacific*

CIGALE: Code Investigating GALaxy Emission

Yannick Roehlly¹, Denis Burgarella¹, Véronique Buat¹, Élodie Giovannoli¹,
Stefan Noll², and Paolo Serra³

¹*Laboratoire d'Astrophysique de Marseille / C.N.R.S. - Université de Provence
38, rue Frédéric Joliot-Curie, 13388 Marseille, France*

²*Institut für Astro- und Teilchenphysik, Universität Innsbruck,
Technikerstr. 25/8, 6020 Innsbruck, Austria*

³*Astrophysics Branch, NASA/Ames Research Center,
MS 245-6, Moffett Field, CA 94035*

Abstract. We present CIGALE (Burgarella et al. 2005; Noll et al. 2009), a software developed at the *Laboratoire d'Astrophysique de Marseille* to fit galaxy spectral energy distributions from the rest-frame far-UV to far-IR wavelength range, and to derive some of their physical parameters. We also give some examples of scientific results obtained with CIGALE.

1. Aim of the software

The multi-wavelength observation of galaxies allows astrophysicists to derive some of their physical parameters from the comparison of their spectral energy distributions (SEDs) to computed SEDs based on models and templates (SED fitting). Scientists from the *Laboratoire d'Astrophysique de Marseille*¹ developed CIGALE (/si.gal/), a Code Investigating Galaxy Emission, that takes into account both the dust ultraviolet-optical attenuation and its corresponding infra-red re-emission. CIGALE is able to statistically derive reliable physical parameters from UV to IR observations.

2. How CIGALE works

The user provides CIGALE with multi- λ fluxes and redshift for each galaxy, and with a list of possible values for each physical parameter. The parameters are those related to star formation history (τ and ages for young and old stellar populations (SP), mass fraction of young SP), dust attenuation (V-band attenuation, reduction factor of A_V for old SP) and dust emission (IR power-law slope, AGN related fraction of L_{dust}).

Using various models, libraries and templates (see figure 1) CIGALE computes all the possible spectra and derives mean fluxes in the observed filter bands. Then a

¹<http://lam.oamp.fr>

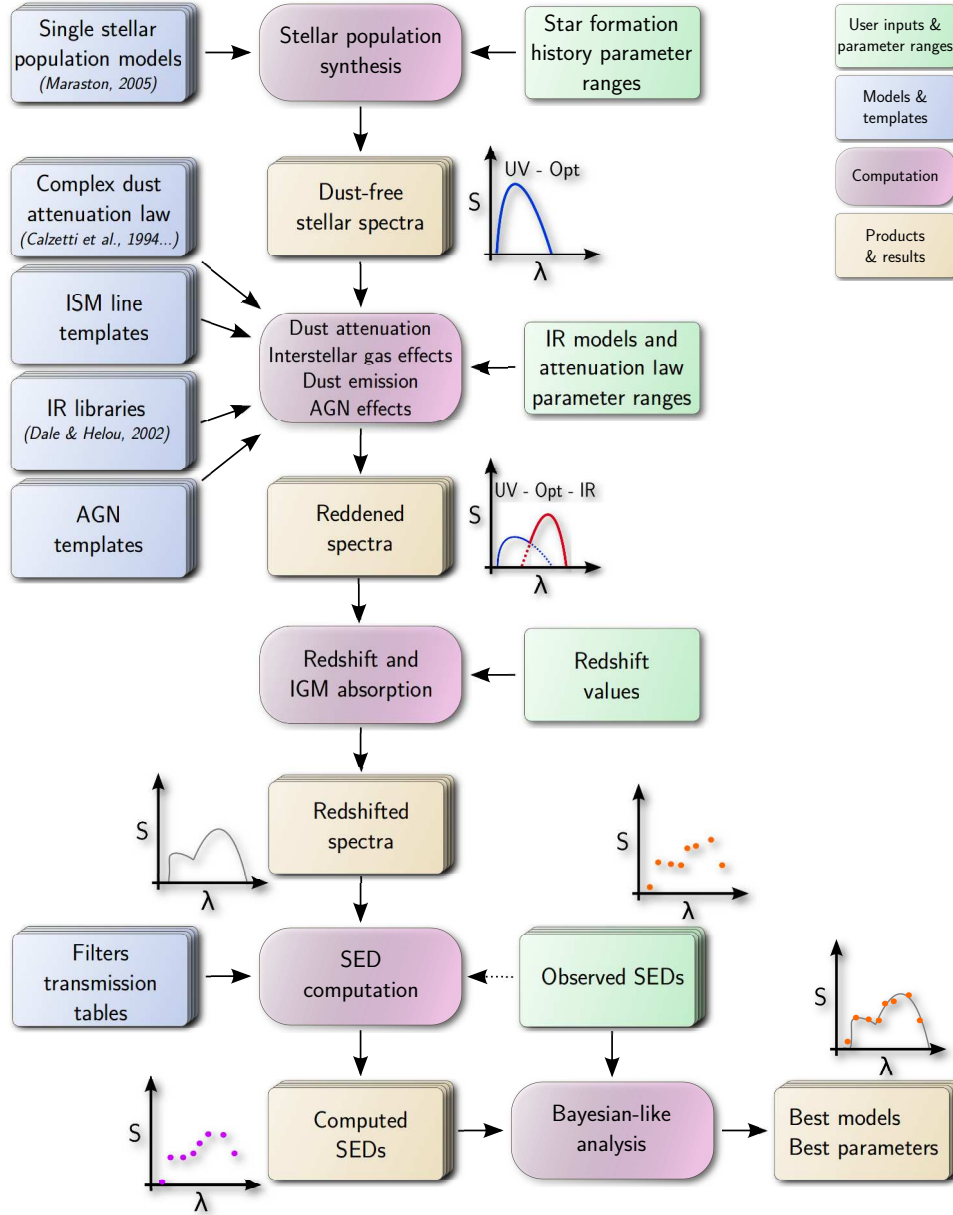


Figure 1. CIGALE operation workflow

Bayesian-like statistical analysis permits to determine for each galaxy the best value for each parameter as well as the best computed model (see figure 2).

3. Example of scientific applications

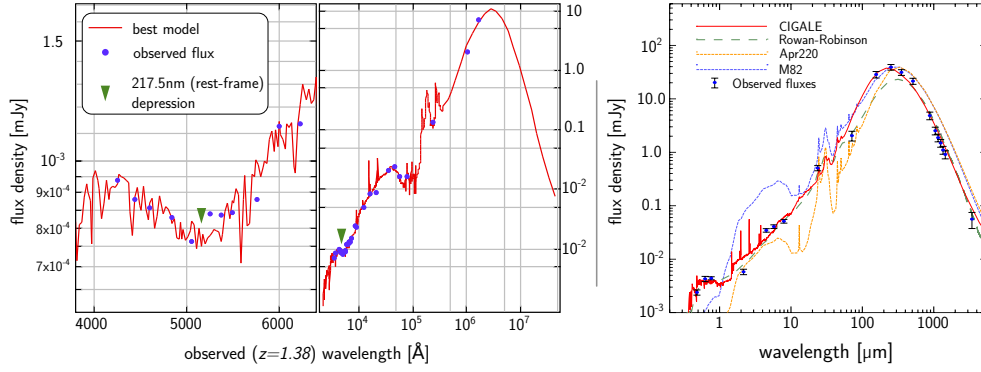


Figure 2. Examples of scientific use. Left: $z = 1.38$ galaxy SED showing 217.5nm depression (Buat et al. 2011). Right: CIGALE fitting of HLSW-01 - adapted from Conley et al. (2011).

3.1. High-redshift galaxy study

Buat et al. (2011) combined photometric data with broad and intermediate band filters, and far-infrared data from Herschel to sample the ultraviolet spectrum of high redshift galaxies and characterize their dust extinction (see figure 2 left). A depression at 217.5nm is clearly identified in all sources. An analytical formula of the dust attenuation curve is deduced from CIGALE with a bump of moderate amplitude at 217.5nm (see also Burgarella et al. 2011; Giovannoli et al. 2011).

3.2. Multiply-lensed galaxy study

Conley et al. (2011) used CIGALE to study the multiply-lensed galaxy HLSW-01 and compute some of its physical properties, in particular its stellar mass, its star formation rate and the proportion of young stars. The right part of figure 2 compares the best CIGALE model to the best combination of templates from Rowan-Robinson et al. (2010) and IR SEDs of Arp220 and M82.

4. CIGALEMC - Using Monte Carlo Markov Chain statistical method

From the CIGALE code base Serra et al. (2011) developed CIGALEMC that uses a Monte Carlo Markov Chain method to find the best fit parameters. CIGALEMC is made to be efficient (needed CPU time grows linearly, not exponentially, with the number of fitted parameters), accurate (statistical quantities are robustly determined using Gelman & Rubin diagnostic as convergence criteria) and user friendly (*a priori* deciding the parameter density, to find a compromise between accuracy and speed, is not necessary).

5. Future evolutions

In addition to Dale & Helou (2002), we want to propose the use of Chary & Elbaz (2001), Siebenmorgen & Krügel (2007) and Draine & Li (2007) libraries, as well as the use of CB07 stellar population model from Bruzual and Charlot² in addition to Maraston (2005).

We are studying the port of CIGALE to Python – presently the code is written in Fortran – for more modularity, more readability of the code and more evolution opportunities.

6. Contact and download

CIGALE is available for download on its web site³, where you will also find an on-line, java applet based, version. For more information on CIGALE software, you can contact Denis Burgarella <denis.burgarella@oamp.fr>.

References

- Buat, V., Giovannoli, E., Heinis, S., et al. 2011, A&A, 533, A93+. 1107.1049
 Burgarella, D., Buat, V., & Iglesias-Páramo, J. 2005, MNRAS, 360, 1413.
 arXiv:astro-ph/0504434
 Burgarella, D., Heinis, S., Magdis, G., et al. 2011, ApJ, 734, L12+. 1105.0646
 Chary, R., & Elbaz, D. 2001, ApJ, 556, 562. arXiv:astro-ph/0103067
 Conley, A., Cooray, A., Vieira, J. D., González Solares, E. A., Kim, S., et al. 2011, ApJ, 732, L35+. 1104.4113
 Dale, D. A., & Helou, G. 2002, ApJ, 576, 159. arXiv:astro-ph/0205085
 Draine, B. T., & Li, A. 2007, ApJ, 657, 810. arXiv:astro-ph/0608003
 Giovannoli, E., Buat, V., Noll, S., Burgarella, D., & Magnelli, B. 2011, A&A, 525, A150+. 1006.5555
 Maraston, C. 2005, MNRAS, 362, 799. arXiv:astro-ph/0410207
 Noll, S., Burgarella, D., Giovannoli, E., Buat, V., Marcillac, D., & Muñoz-Mateos, J. C. 2009, A&A, 507, 1793. 0909.5439
 Rowan-Robinson, M., Roseboom, I. G., Vaccari, M., et al. 2010, MNRAS, 409, 2. 1006.0120
 Serra, P., Amblard, A., Temi, P., Burgarella, D., Giovannoli, E., Buat, V., Noll, S., & Im, S. 2011, ApJ, 740, 22. 1103.3269
 Siebenmorgen, R., & Krügel, E. 2007, A&A, 461, 445. arXiv:astro-ph/0606444

²<http://bruzual.org/cb07/>

³<http://cigale.oamp.fr>